

TWELVE YEAR SURVEY OF THE SUSCEPTIBILITY OF WOMEN  
TO ALTITUDE DECOMPRESSION SICKNESS

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**INTRODUCTION** In 1973 it was reported that the incidence (#cases/#exposures) of decompression sickness (DCS) requiring hyperbaric therapy was significantly greater in women (0.219%) exposed in altitude chambers at the USAF School of Aerospace Medicine (USAFSAM) than in men (0.022%) similarly exposed ( $\chi^2$ ,  $p < 0.005$ ). In the period covered, from 1968 through 1972, the total number of students throughout the USAF treated for DCS numbered 17 (8 women/9 men). In comparing the cases it was concluded that women had a more complex pattern of effects, recurrences and response to therapy (1).

Because the majority of DCS cases in women occurred in Flight Nurses undergoing training at the USAFSAM, since 1973 women in the Flight Nurse and Aeromedical Evacuation Technician courses have been exposed to lower altitudes on the two required chamber exposures than men and women in other courses at the USAFSAM and at all other USAF physiological training units.

This report compares the incidence of DCS in women and men at the USAFSAM for the 5-year period from 1 Jan 73 through 31 Dec 77 with the previous 5-year experience. Further comparisons between men and women were obtained from analyses of 104 USAF-wide cases of altitude DCS treated by hyperbaric therapy during the 12-year period from 1966 through 1977.

**METHODS** The total number of exposures to altitudes greater than 18,000 feet at the USAFSAM was obtained from AF Forms 700 (Physiological Training Program Monthly Report) for the 5 calendar years 1973 through 1977. The number of women exposed was obtained from AF Forms 699 (Physiological Training Record) for the same period. Male exposure data were obtained by subtracting the number of exposures of women from the total number of exposures.

Information and data regarding all DCS cases were taken from AF Forms 361 (Chamber Reactor Case Report), AF Forms 1352 (Treatment Record), narrative summaries and hospital or other records, as required.

U.S. Air Force total altitude chamber exposure data were obtained from records maintained in the office of the Chief of Aerospace Physiology, HQ USAF, Surgeon General's Office.

**RESULTS** The overall incidence of DCS at the USAFSAM from 1973 through 1977 was 29 cases out of 12,465 exposures (0.23%). In the previous 5-year period the overall incidence was 0.074%. Of the 29 cases, 15 (52%) occurred in men and the incidence in men was 15/9,864 (0.15%). The incidence in men for the previous 5-year period was 0.022%. The incidence in women was 14/2,601

(0.54%) compared with an incidence of 0.219% from 1968 through 1972. The greater incidence of DCS in women compared to men is statistically significant by  $\chi^2$ , for both 5-year periods ( $p < 0.005$ ). However, because of the greater increase in incidence in men than in women in 73-77 compared to 68-72, the difference in incidence has decreased from tenfold to three and one-half fold.

For the 73-77 period the incidence of DCS for students participating in chamber training at all USAF Physiological Training Units (excluding students at USAFSAM and AF Academy Cadets) was 60/222,425 (0.03%). Forty-two (70%) received hyperbaric therapy compared to only 19% in the 68-72 period. Of the 60 cases, 49 (82%) occurred in men and 11 (18%) occurred in women. Because the Air Force-wide number of exposures for men and women cannot be separately determined readily, no difference in incidence has been determined.

Analyses of 104 students treated for DCS in the 12-year period (1966-1977) reveal significant differences between the men (72) and women (32) with respect to many individual and exposure factors, and in the nature of their disorder. Women with DCS were shorter and lighter than the men with DCS. A higher percentage of women with DCS were judged to be slender and had a history of migraine/vascular headaches and/or a previous altitude reaction. The percentage of women with DCS based on maximum exposure altitude of less than 34,000 feet was greater than men with DCS. A higher proportion of women with DCS had the onset of Type I DCS while at altitude, had recurrences of symptoms during/following treatment, and had cutaneous manifestations of DCS. Finally, only 2 women and no men had neurological defects following hyperbaric therapy.

Three other groups within the total USAF population exposed were found to have a significantly greater incidence of DCS than the 0.03% in all other USAF students during the 73-77 period. These groups were: Air Force Academy Cadets trained at Peterson AFB CO (12/1,654, 0.73%); Pararescue students trained at the USAFSAM (4/804, 0.50%); and altitude chamber inside observers (61/59,925, 0.10%). Furthermore, the incidence of DCS in cadet women (3/155, 1.94%) was over three times as great as the incidence in cadet men (9/1,499, 0.60%).

**DISCUSSION** While the difference in incidence of altitude DCS between men and women exposed at the USAFSAM has decreased, the difference remains statistically significant. When compared statistically, there is no significant difference in incidence between AF Academy Cadet men, pararescue students, and women at the USAFSAM. Further evidence that there is a greater incidence

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of DCS in women is seen in the AF Academy Cadets and in women scuba diving instructors. Bangasser reported a threefold greater incidence in this latter group (0.023%) which was statistically significant when compared to male scuba instructors (0.007%) in the same geographical region (2).

Additional evidence of the difference is found in the analyses of factors among the 72 men and 32 women treated for DCS in the period 1966-1977. The women in this group were statistically smaller (height, weight and body build) which would result in a lower total quantity of dissolved nitrogen and presumably a decreased likelihood of developing DCS. This assumption ignores the contribution of body fat to DCS susceptibility, which has been shown to increase an individual's likelihood of experiencing altitude DCS (3). Unfortunately, there are no data available on the percentage of body fat in either the women or the men in this group. The fact that a significantly greater proportion of women in this group developed DCS at lower altitudes than the men indicates an increased susceptibility. This also reflects the fact that the reduction in peak exposure altitudes for women in Flight Nurse and Aeromedical Evacuation training did not reduce the incidence of DCS. Increased sensitivity to DCS in women may also be indicated by the fact that a greater proportion of women suffering from Type I DCS (i.e., bends pain only) had onset of symptoms while at altitude.

The observation that women with DCS have more recurrences and more lasting neurological defects originally reported in 1973 (1) and again in 1977 (4) remains apparent in the analyses of these 104 cases of DCS. This finding is at least as significant as the finding of an increased incidence in women. The basis for the greater severity or complexity of DCS in women may be that bubbles formed on decompression trigger more severe secondary effects such as hematological changes (5), release of vasoactive substances (6), or dynamic vascular changes (7) because of some underlying constitutional differences in women. The growing evidence that the occurrence of DCS is multifactorial in nature makes the analysis of apparently susceptible subgroups of the total exposed population very difficult. For example, there may be a common denominator or combination of factors in common that would explain the higher and equal incidence in the AF Academy Cadets, pararescue trainees and women at USAFSAM. There are some definite correlations between the cadets and the pararescue students, but any commonality between women, and these two groups remains obscure.

The increase in DCS incidence in both men and women at the USAFSAM 1973-1977 compared to the earlier 5-year period deserves some comment. This increase is also found in the remainder of the USAF. In 1968-1972 only 6 men and 1 woman exposed to altitude at facilities other than USAFSAM were treated for DCS. From 1973-1977, 35 men and 7 women, excluding USAFSAM students and AF Academy Cadets, were treated for DCS. In the 8 years

from 1966-1973 only 37% of all DCS case received hyperbaric therapy, while 81% were treated in the years 1974 through 1977. Type I DCS cases showed an even more marked difference, increasing from 20% treated to 82% in the same time interval. These findings are felt to be indications of the increased emphasis on early recognition, reporting of symptoms, diagnosis and conservative management of DCS cases in USAF personnel, which can be related to the establishment of the full-time hyperbaric therapy unit at the USAFSAM in 1974.

**SUMMARY AND CONCLUSIONS** The greater incidence of DCS in women originally reported in 1973 has continued to exist among students exposed to altitude at the USAFSAM in spite of lowering the peak exposure altitudes for Flight Nurse and Aeromedical Evacuation students. This in itself indicates a greater susceptibility among women. Furthermore, an increased DCS incidence in women has now been reported among AF Academy Cadets and sport scuba diving instructors. No similar observations have yet been reported for women military aviators, NASA astronauts or for women in military or commercial diving.

Explanations for the greater incidence and the more severe nature of DCS in women are still lacking. As suggested in 1973, studies designed to find the causes for these differences in women may eventually lead to a better understanding of the etiology of DCS and the interrelationships between various known and unknown factors contributing to individual and group susceptibility.

#### REFERENCES

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